GROUP 16

Axle - Chassis Design.

Group meeting: ~~[illegible]~~ 2nd March.

Members	RC parts
Can	Traxxas 20-Turn Stinger Performance 540 Motor - DC Motor
Tony	Venom 7.2V 3000mAh 6-cell NiMH - Battery
Ethan	Futaba S3003 Standard Servo - Servo.
Mate	Hobbywing Quic Run 1/10 Waterproof Brushed 60A selection speed controller 1060 - Speed controller
Rohit	SR315 Receiver, SPM2340 - Radio receiver
	Spektrum DX3 Smart 3-Channel Transmitter - Remote Control.

Aim: Designate design, modelling, calculation & documentation roles for axle-chassis design.

① Discuss overall concept for the car.

Component net weight :- 0.5kg.

Top Speed Calc. (Unloaded)

K_v : is the measurement for RPM/Volt

Voltage = 7.2V (Battery voltage).

$\therefore RPM = k_v * V \ldots \ldots$ ①

$1 rev/min = \frac{2\pi}{60} rad/s = \frac{\pi}{30} rad/s.$

$\therefore \omega = RPM * \frac{\pi}{30} \ldots \ldots$ ②

$V = \omega r \ldots \ldots$ ③

$\therefore v = ((K_v * V) * \frac{\pi}{30}) * r$ $[K_v = 540 rpm/V, V = 7.2V]$

if $r = 0.038m.$

$v = ((540 * 7.2) * \frac{\pi}{30}) * 0.038 = 15.47 ms^{-1}$

From $k_t = \frac{\cancel{1352.4} 60}{k_v * 2\pi}$ (k_t : units: oz-in/A) (Motor constants relation)

in N-m: $k_t = \frac{\cancel{1355} 30}{\cancel{0.00706} * k_v * \pi}$ (1oz-in = 0.00706Nm) => $k_t = 1.919 \times 10^5 k_v$

$\tau = K_t * I \therefore$ ~~[illegible]~~ $\tau = \frac{30 * I}{K_v * \pi}$

From

$$P = \tau * \omega$$

$$\cancel{P = \frac{30 * I}{K_v * \pi} * \omega} \quad \cancel{IP = IV}$$

$$\cancel{I * V = \frac{30 * I}{K_v * \pi} * \omega} \quad \cancel{I * V = \tau * \omega}$$

$$\cancel{\tau = \frac{I * V}{\omega}}$$

$$\tau = \frac{30 \times I}{K_v \pi}$$

Aim: To complete 3 laps in 20 sec.

$1 \text{ lap} = \frac{20}{3} s$

1 lap (middle lane) $\simeq (3_m + 13_m) * 2 = 32m$.

$$\therefore V_{avg} = \frac{32}{\frac{20}{3}} = \frac{96}{20} = 4.8 m/s$$

To compensate for reducing speed from rounding curves; $v_{max} \simeq 6 m/s$

Max acc (From zero to V_{avg}, 0.5 sec)

$a_{max} = 9.6 m/s^2$

Max acc from turning a corner at $0.5 v_{avg}$ to v_{avg} in 0.3s

$$a = \frac{0.5 v_{avg}}{0.3} = 8 m/s^2$$

$$8 m/s^2 < a_{max} < 9.6 m/s^2$$

Calc Impact Forces

$v_i = 6 m/s$

$m = 0.7 kg$

$K_{chassis} = 5.55 \cdot 10^{\circ} N/m \; (8.048 \times 10^{-2} * E_c)$

$K_{axle} = 5.43 \times 10^{-9} * E$

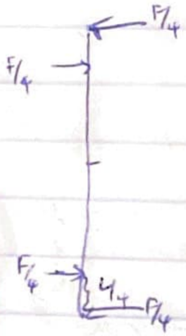
$$\frac{1}{K_{total}} = \frac{1}{K_{chassis}} + \frac{2}{K_{axle}} \Rightarrow K_{total} = \frac{1}{\frac{1}{8.048 \times 10^{-2} E_c} + \frac{2}{5.43 \times 10^{-9} E_a}}$$

$$= \boxed{\frac{E_c * E_a * 2.185 \times 10^{-10}}{(8.048 \times 10^{-2} E_c + 2.715 \times 10^{-9} E_a)}}$$

Assuming $k = 0.2 N/m$

$F = \sqrt{17 m k}\,(6 m/s)$

$= 2.24 \, N$



$M_{max} = \left(\frac{3L}{4} \times \frac{F}{4}\right) - \left(\frac{F}{4} + \frac{L}{2}\right) + M = 0$

$M = \frac{FL}{8} - \frac{3FL}{16} = \frac{2FL}{16} - \frac{3FL}{16} = \frac{-FL}{16}$

$\sigma = \frac{Mc}{I} = \frac{\frac{3FL}{16} \times \left(\frac{0.003}{2}\right)}{\frac{\pi (0.003)^4}{64}} = 2.36 \times 10^7 FL$

$= 6.87 MPa$

$\sigma_{max\ chassis} = \frac{F}{A} = \frac{2.24}{(0.13)^2 (0.04)} = 0.43 kPa.$

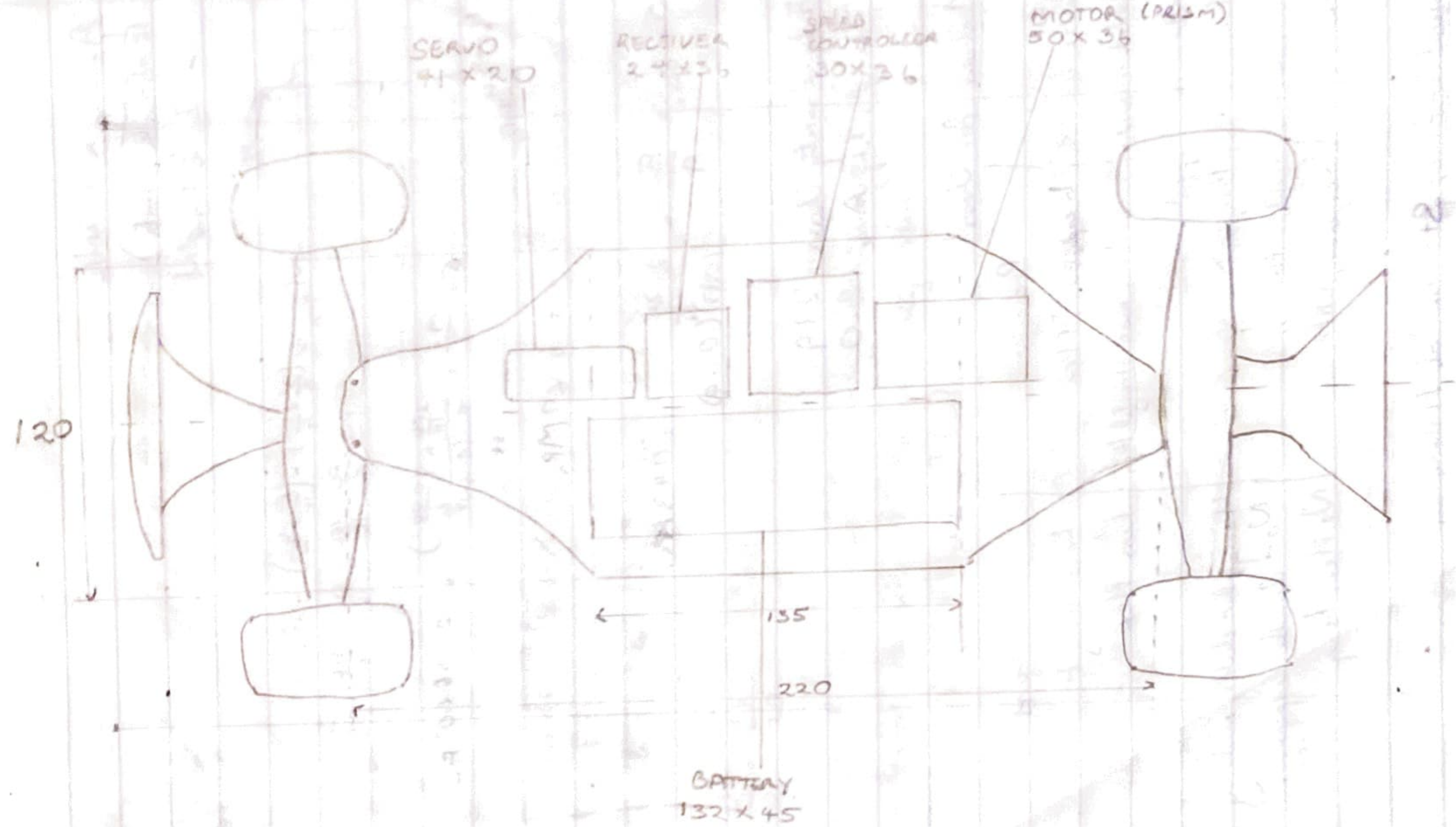
Factor of safety Chassis: 2.19

Factor of safety Axle: 2.0

<u>Material for Chassis</u>

	Pro	Cons
Plastic	Inexpensive, Flex	Low strength
Molded reinforced Plastic	" , more strength than plastic	Less flex
Aluminium.	Rigid, Durable,	Heavy for electric, machining is expensive.
Woven carbon fiber	Light, stiff	Not durable, expensive.
Wood	Inexpensive, stiff	No flex, heavy.

<u>Material for Axle</u>: Stainless Steel / Aluminium



SERVO
41 X 20
RECIEVER
24 X 36
SPEED
CONTROLLER
30 X 36
MOTOR (PRISM)
50 X 36
120
135
220
BATTERY
132 X 45

Suggestion for servomotor & steering connection.

Recalculations after meeting

Chassis Area Calculation.

$\rho_{AL} = 2710 kg/m^3$, $E_{AL} = 69 GPa$

$D_A = 3mm = 0.003m$.

$A_c(13.36) = (\pi \times (13.5)^2) - (\pi \times (5.5)^2) + (3.2) - (4.5.7) - (2.75 \times 7)$.

$A = 289.73 cm^2 = 0.029 m^2$

$V = At = 0.029 \times 2.10^{-3} = 6 \times 10^{-5} m^3$

$m_{chassis} = 6 \times 10^{-5} \times 2710 = 0.16 kg$

$$K_{chassis} = \frac{EA}{L_c}$$

$$= \frac{69 \times 10^9 \times 0.029}{0.36}$$

$$= 5.5 \times 10^6 N/m$$

$$K_{axle} = \frac{3EI}{L^3}$$

$$= \frac{3 \times 6.9 \times 10^6 \times \frac{\pi (0.003)^4}{64}}{(0.13)^3}$$

$$= 0.37 N/m$$

$$k_T = \frac{1}{\frac{1}{k_{axle}} + \frac{1}{k_{axle}'} + \frac{1}{k_{chassis}}}$$

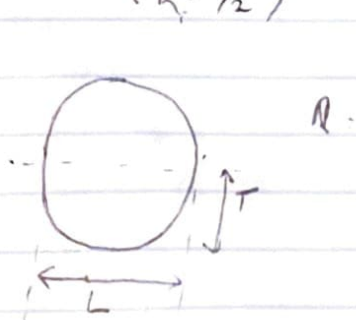
$$= \frac{1}{5.41} = \boxed{0.2N/m}$$

<u>Steering Angle</u> - <u>Recalculation</u>

$\therefore \tan\alpha = \frac{0.5}{2.5} \Rightarrow \alpha = \tan^{-1}\left(\frac{1}{5}\right) = \boxed{11.3^\circ}$

For δ

$$\delta_i = \tan^{-1}\left(\frac{L_i}{R_i - T/2}\right)$$



L = Wheelbase of the car.

T = Distance between the centerline of each car.

$\therefore$ $L_1 = 15cm$, $T_1 = 7cm$, $R_1 = 1.9cm$

$L_2 = 15cm$, $T_2 = 7cm$, $R_2 = 1.5cm$.

$$\delta_1 = \tan^{-1}\left(\frac{0.15}{1.54 - \frac{0.07}{2}}\right)$$
$$= 44.9^\circ$$

$$\delta_2 = \tan^{-1}\left(\frac{0.15}{1.9 + \frac{0.07}{2}}\right) = 43.6^\circ$$

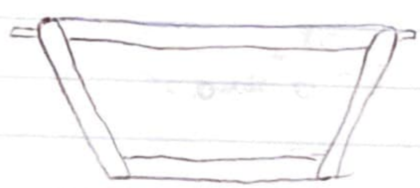
$$T_R = \frac{L}{\tan(\delta_i)}$$

$$T_R = \frac{0.15}{\tan(44.9^\circ)} = 0.15\,m$$

<u>For 30°</u>

$$T_R = \frac{0.15}{\tan(30^\circ)} = \boxed{0.26\,m}$$

<u>Final Steering Mechanism</u>: Ackerman Steering.



<u>Pros:</u>

No slipping.

Drive independently.

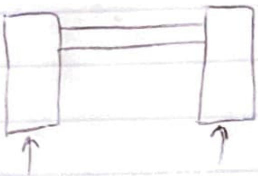
<u>To-Do</u>

Work on drivetrain ratio.

Joint Analysis.

Read Ackerman Steering.

Drive train Ratio



For Friction

$F = \mu R$

$\mu = 0.85$ (From internet, Soft rubber on concrete)

$2kg(9.81) \times 0.55 = 16.66N.$

For Drag:

$\mathcal{D} = \frac{1}{2} \rho U^2 A C_D$

$C_D = 0.3;\ \rho = 1.725;$

$A = 2 \times 0.025 \times 0.062 + \cancel{0.002 \times 0.08} + 0.06 \times 0.08 =$

$A = 0.025 \times 0.062 \times 2 + 0.002 \times 0.08 + 0.06 \times 0.08 =$

$= 0.007 m^2$

$\therefore \mathcal{D} = \frac{1}{2}(1.725 \times 0.007 \times 0.3 \times (4.8)^2)$

$= 0.0441N$

$\therefore \Sigma F = 16.6 + 0.0441 \approx 16.6N$

$\therefore \tau = (16.6) \times (0.03) = 0.501 Nm = 501 Nm.$

$\frac{\tau_{in}}{\tau_{out}} = \varepsilon \frac{\omega_{out}}{\omega_{in}}$

$\therefore \mathcal{E} = 90\%$

$\frac{\omega_{gen}}{\omega_{in}} = \frac{N}{N_2} = \frac{501}{90} \times 100 = 1:5.56777$

Making Drawing

Gear ratio

Joints

Gear ratio - Recalculation Area = Same ; C_D = Same, F_0 = Same.

$F_D = \frac{1}{2}(1.225) \times 0.007 \times 10^2 \times 0.3 = 0.1286\,N$

$\Sigma F = 16.66 + 0.1286 = 16.7886\,N$

$r \times F = \tau$

$0.03 \times 16.7886 = 0.503\,N.m$

$503\,mN.m$

10 : 55

$\therefore \mathcal{E} = 94\%$

$\therefore$ The gear ratio will be 1 : 5.17

For 97.29 mNm on motor

$12\,000_{rpm} \div 60 = 200_{rps}$

$D = 6_{cm}$

Circumference: $0.06\pi = 0.1885\frac{m}{R}$

$\frac{200\,R}{s} \times \frac{1}{5.17} \times 0.1885 = 7.29\,m/s$

$F_D = \frac{1}{2}(1.225) \times 0.007 \times (7.29)^2 \times 0.3 = 0.0068N$.

$\Sigma F = 16.66 + 0.0066 = 16.728$

$\therefore \tau = 16.728 \times 0.03 = \boxed{0.514 m}$

<u>R we decrease ratio. For 1:4</u>

$\omega_s = 0.06$

$\omega_{car} = 0.188$

$\therefore \frac{1}{4} = \frac{0.503}{83.94} = \frac{\omega_{out}}{5000}$

$\therefore \omega_{out} = 133.33$.

$\omega_{wheel} = 33.33$.

$v = \omega r = 0.03 \times 33.33 = \boxed{6.283 m/s}$

<u>For increasing rpm</u>

rpm = 1350.

$\frac{1350}{\omega_{out}} = \frac{6}{1} \Rightarrow \omega_{out} = \frac{1350}{6} = 22.5$

$\therefore \omega_{wheel} = 0.03 \times 22.5 = \boxed{0.726 m/s}$

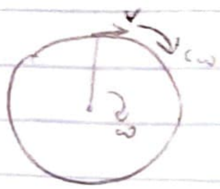
<u>Max acceleration calculations Redo</u>

Using stall orqe: 196(mN m)

$t_R = \frac{\omega_{out}}{\omega_{in}} = L_{gears}\left(\frac{\omega_{out}}{\omega_{in}}\right) \cdot \left(\frac{\omega_{out}}{\omega_{in}}\right] = \frac{2}{5.5}$

$T_{out} = \frac{196}{1/5.5} = -1078 mN$

⑤



$\omega = \frac{v_{cm}}{R}$, $\alpha = \frac{a_{cm}}{R}$

$f_s = \mu_s N$, $\therefore f_s = \mu_s m g$

$\therefore \Sigma F_x = 0 = \vec{F} - f_s = 0 \, m_g$

$\Sigma F_y = \vec{N} = \mu_s \vec{P}$

$\Sigma M = FR$

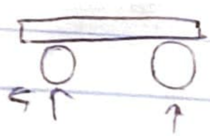
$\therefore \mu_s = 0.05$

~~$F_s = 0.128N$~~

$F_s = 0.128N$

$F = (0.85)(2.4528 - 0.128) = 2.213N.$

d.



$\Sigma F_x = ma.$

$F_m - F_s - F_r = ma.$

$F_m = 0.1286N + 16.6N = 16.786N.$

$\therefore a = \boxed{16.79 m/s^2}$

Drivetrain ratio Update after purchase

$TR = 1:3.38$

$v_{max} \Rightarrow 5.52 m/s$

$a_{max} = 12.72 m/s^2$

Meeting

Joint Analysis

Rest of Orders

Water jet??

$TR = \frac{0.226}{\tan 30} = 0.39 m.$

Meeting

Aluminum Sheet?

Machine Shop?

Gears?

Nuts & Bolts.